

PURPOSE: NASA-MUST final technical report

SUBJECT: Scientific Verification Test of Orbitec Deployable Vegetable Production System for Salad Crop Growth on ISS- Gas Exchange System design and function

DATE : August 3, 2007

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1. BACKGROUND

The ability to produce and maintain salad crops during long term missions would be a great benefit to NASA; the renewable food supply would save cargo space, weight and money. The ambient conditions of previous ground controlled crop plant experiments do not reflect the microgravity and high CO₂ concentrations present during orbit. It has been established that microgravity does not considerably alter plant growth. (Monje, Stutte, Chapman, 2005). To support plants in a space-craft environment efficient and effective lighting and containment units are necessary. *Three lighting systems were previously evaluated for radish growth in ambient air; fluorescent lamps in an Orbitec Biomass Production System Educational (BPSE), a combination of red, blue, and green LED's in a Deployable Vegetable Production System (Veggie), and a combination of red and blue LED's in a Veggie.* When mass measurements compared the entire possible growing area vs. power consumed by the respective units, the *Veggies clearly exceeded the BPSE indicating that the LED units were a more resource efficient means of growing radishes*

under ambient conditions *in comparison with fluorescent lighting*. To evaluate the most productive light treatment system for a long term space mission a more closely simulated ISS environment is necessary. To induce a CO₂ dense atmosphere inside the Veggie's and BPSE a gas exchange system has been developed to maintain a range of 1000-1200 ppm CO₂ during a 21-day light treatment experiment.

This report details the design and function of the gas exchange system. The rehabilitation, trouble shooting, maintenance and testing of the gas exchange system have been my major assignments. I have also contributed to the planting, daily measurements and harvesting of the radish crops 21-day light treatment verification test.

2. MATERIALS AND METHODS

2.1 *Mixing tank*

A CO₂ gas cylinder and buffered ambient air line (pumped) are connected to a six inch diameter PVC mixing tank. The mixing tank host four feed lines, one to each the light treatment chambers (3) and the other to the infrared gas analyzer (IRGA).

2.2 *Infrared Gas Analyzers (IRGAs)*

The system has two IRGAs, their operating range is 0-3% CO₂; accuracy: 0.1; optical path length: 15 cm; and a signal –to- noise ratio of 4000:1. Calibration tests determined that they could measure differences in CO₂ of 5 $\mu\text{mol mol}^{-1}$ against a background of 0.9% CO₂, this permits the measurement of photosynthesis and respiration rates. (Monje et al., 2000). One IRGA measures pre-chamber gas (absolute CO₂), the other post-chamber gas (differential CO₂). The IRGAs scrubbers contain a 1:1:2.5 layer of Mg (ClO₄)₂: indicating drierite (anhydrous calcium sulfate): soda lime.

The feed from the tank flows to the absolute IRGA sample line and the differential IRGA reference line. Both the different, absolute IRGA, and all solenoids are connected to the data-logger.

The IRGAs are calibrated weekly at 0, 1500, and 2500 ppm CO₂. The scrubber materials are replaced when the Mg (ClO₄)₂ becomes saturated.

2.3 Light treatment chambers

Each chamber has two gas flow connections; the inlet feed line from the mixing tank and an outlet sample line via solenoids to the differential IRGA. Each chambers' sample concentration is measured and analyzed individually over a programmable time interval. Chamber feed flow rates range 10-15 LPM, sample flow rates to the differential IRGA range 3-4 LPM and must be equivalent to the differential IRAG reference lines' flow rate.

All three chambers feed lines have been attached to small 0.96W, 12VDC fans inside the chambers for air circulation. The Veggies four internal fans have been modified; they were detached from the light panel to hang freely into the chamber. These alterations decreased air leaks and add to the overall circulation.

2.4 Growth analysis calculations

The previous experiments done with these light treatments have expected net photosynthesis and plant development curves for each chamber. With the gas exchange system it is easy to alter the internal CO₂ levels and record the resulting net photosynthesis and plant stand evapotranspiration rates. (Evapotranspiration is the sum of the movement of internal water through a plant and the evaporation of water from a plant into the surrounding atmosphere).

3. RESULTS AND DISCUSSION

Comparison with established data offers insight in the effect of the high CO₂ concentrations on the crop development under each lighting treatment. This study hypothesizes that crops growth in a CO₂ dense atmosphere will have less mass and or leaf area than those grown in ambient air. At this date the crop light treatment verification test is in its final stages but not complete. Thus, final results and comparisons have not been collected and examined.

REFERENCES

- Monje O, Stutte G, Chapman D (2005) Microgravity does not alter plant stand gas exchange of wheat at moderate light levels and saturating CO₂ concentration. *Planta* 222:336-345
- Monje O, Bingham G.E, Carman J, Campbell W., Salisbury F, Eames B, Sytchev V, Levinskikh M, Podolsky I (2000) Canopy Photosynthesis and Transpiration in Microgravity: Gas Exchange measurements aboard MIR